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Monitoring Residual Herbage in Wind Cave National Park 2010 – 2013 Using Modified Robel Pole Protocol Calibrated for the Southern Black Hills

Natural Resource Data Series NPS/WICA/NRDS—2014/641

ON THE COVER
Wind Cave National Park vegetation crew members collecting residual herbage data using the modified Robel pole protocol calibrated for the southern Black Hills on the Casey addition in 2013.
Photograph by: Beth Burkhart, Wind Cave NP

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Abstract

The Wind Cave National Park (WICA) Robel project used a simple, precise, and economical tool (the Robel pole calibrated for the southern Black Hills) to characterize WICA residual herbage over four years from 2010 through 2013. The primary objectives of the project were to determine condition of residual herbage on a park-wide basis for this time period and present results in a clear and simple manner.

WICA Robel project results are that the grassland areas of the park grazed by bison and other wildlife were above Robel band 3 in every year from 2010 through 2013 (three out of four above-average precipitation years). This is the target level determined by research (Uresk et al. 2009) that leaves 60% of potential yield and is supportive of long-term plant health and ecological health for rangelands in the southern Black Hills.WICA Robel project results also include that vegetation in mixed-grass prairie with prairie dogs from 2010 through 2013 was below the level of Robel band 5 recommended by Robel research (Uresk and Mergen 2012) to maintain prairie dog towns with limited or no expansion. This indicates there was some potential for expansion.

Residual herbage is just one component to consider in assessing ecological health of WICA relative to herbivores. Another important rangeland resource is water. Results of residual herbage and stream monitoring suggest that under recent past and current management, water rather than vegetation is a limiting factor for WICA ecological health. That is, the present numbers of wildlife (in present management style) are causing poor surface water resource condition while residual herbage has been maintained in good condition.

Both water and vegetation must be wisely managed to meet long-term natural resource stewardship goals at WICA. Monitoring residual herbage in real-time, as the Robel pole protocol allows, is an important tool for understanding WICA vegetation condition. It can provide an early warning system for herbage resources under stress and combine with other resource monitoring to maximize the time available for making management choices that conserve all intertwined park resources (e.g., grazed vegetation, non-grazed vegetation, surface water, soils, and wildlife).

Acknowledgments

We thank WICA seasonal vegetation crew members 2010 through 2013 for helping collect WICA Robel field data, especially Kevin Miller who led Robel teams every year.

Daryl Mergen assisted WICA in collecting Robel data during several years of the project and provided valued input to discussions about WICA Robel project design and data analysis.

Dan Uresk has been very helpful in answering questions about Robel pole calibration and rangeland management over the last four years, including making trips to observe WICA rangelands and to brainstorm on monitoring and rangeland management. His significant investment of time and effort in calibrating the Robel pole to measure residual herbage throughout the northern Great Plains has resulted in a practical tool that makes monitoring to support management of long-term rangeland health readily achievable.

List of Acronyms

BHCI	Black Hills Community Inventory
BLM	Bureau of Land Management
in	inch
kg/ha	kilogram/hectare
lb/ac	pounds/acre
m	meter
MIM	Multiple Indicator Monitoring of Streambanks and Streamside Vegetation
NGP I&M	Northern Great Plains Inventory and Monitoring Network
NPS	National Park Service
WICA	Wind Cave National Park

Introduction

Wind Cave National Park (WICA) encompasses 33,851 acres in the southern Black Hills of South Dakota (Figure 1). The general purpose of the park is to protect the unique resources of Wind Cave and preserve and enhance mixed-grass prairie and native wildlife, while providing for the enjoyment of the public (WICA Foundation Statement 2011). The park is a mosaic of ponderosa pine forest and mixed-grass prairie, with approximately 70% covered with mixed-grass prairie.

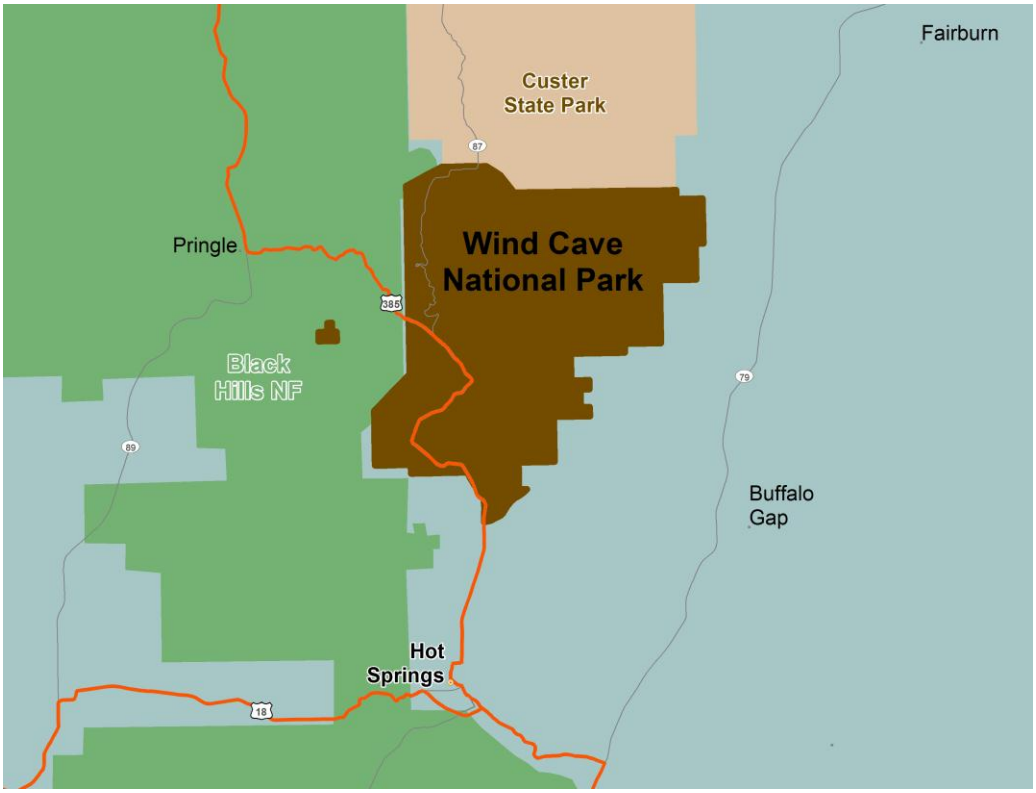


Figure 1. Wind Cave National Park and vicinity in the southern Black Hills.

At a finer level of detail, one part of WICA's purpose is to preserve and enhance mixed-grass prairie, ponderosa pine, and riparian plant communities (WICA Foundation Statement 2011). The interaction of climate, geologic substrate, geomorphology, fire and soils determines the types of vegetation in the park. Vegetation and water provide the ecological foundation for wildlife, as well as many natural processes occurring in the park. Desired conditions in WICA include maintaining and protecting healthy plant communities and hydrological processes (including quality and quantity of surface and subsurface water) to support wildlife, vegetation, and cave resources (WICA Foundation Statement 2011).

WICA was recognized in the Black Hills Community Inventory (BHCI; Marriott et al. 1999) as an exemplary site – a site with outstanding size, outstanding landscape context (including little landscape fragmentation), a diverse set of plant community types present, and high quality occurrences for those types. WICA was noted as including 22 plant community types, including 9 rare community types. Four of these rare plant community types are found in wetlands/streams and woody draws, three are forest types, and two are grassland types. Vegetation is dynamic and varies

over time as a result of precipitation, temperature, use by herbivores [small (i.e., prairie dogs) to large (i.e., bison)], and fire (wildfire and prescribed fire). Park management has no influence on several of these factors. However, herbivore characteristics (e.g., population sizes, age classes, and distribution) and prescribed fire are two factors that provide tools that managers can use to affect changes in park vegetation and ecology.

Another part of WICA's purpose is to preserve and enhance native wildlife populations including bison, elk, pronghorn, mule deer, whitetail deer, and prairie dogs (WICA Foundation Statement 2011). Desired conditions in WICA include healthy animal populations. The target for elk population from the WICA 2006 Elk Management Plan is 232 to 475 animals. The target for bison in WICA from the 2006 Bison Management Plan is 350 to 500 animals, with recommendation of a minimum herd size of 400 to maintain the park's valued bison genome. Park wildlife numbers have varied widely over time. In 1999 (time of BHCI), there were 250-300 elk in the park and approximately 325 bison (D. Roddy pers. comm. 2014). In 2004-2006, spring estimates of elk in WICA were 700 to 850 elk (WICA 2006 Bison Management Plan). In 2012, there were approximately 900 elk in WICA. In 2013, a reduction of about 300 elk occurred in February, leaving approximately 600 elk and 400-450 bison (D. Roddy pers. comm. 2014). In 2014, an additional reduction of approximately 160 elk occurred in March (G. Schroeder pers. comm. 2014).

High animal numbers can contribute to stress on vegetation and other resources, with increasing effects over time due to interactions with other factors such as low precipitation. The difference in animal numbers between 1999 and 2013 likely contributes to different vegetation conditions, particularly in plant communities with limited distribution that are regularly used by wildlife. Variation in precipitation also contributes to different expressions of plant communities and herbage productivity between 1999 and 2013. Vegetation evaluation in WICA comparable to that of the BCHI in 1999 has not been repeated since that time. Conversely, WICA residual herbage was not evaluated in 1999 nor at any time until the 2010-2013 WICA Robel project.

WICA has based its target animal population levels on established protocols by the Soil Conservation Service (in the 1960s) and its evolved organization, the Natural Resource Conservation Service (in 2004). Soils, annual precipitation, and estimated forage production were used to determine estimates of herbivore populations (e.g., bison, elk, pronghorn, mule deer, and black-tailed prairie dogs). Forage resources are allocated as follows: 25% for large mammal (bison and elk) forage; 25% for other wildlife habitat and to compensate for damage to plants (e.g. trampling, hail, etc.); and 50% retained to ensure plant health and vigor (2006 WICA Bison Management Plan). A forage-based management strategy for WICA wildlife /vegetation was established in 2004 based on calculations using a weighted moving-mean for growth year precipitation. Another model to predict WICA forage production was completed in 2010 (Keller and Millspaugh 2010) that was based on spring precipitation, previous year spring precipitation, last date of spring frost, range/woodland site, canopy cover, elevation and a categorical prairie dog colony variable.

These models have been very useful to WICA for determining target herbivore population numbers. They have also been informative to managers with respect to providing some insight into stress/deterioration of long-term plant health when animal populations are over targets. However, the models are unable to provide scientific data or analysis on real-time impacts of high animal populations to actual WICA herbage resources. One result is the inability to develop triggers that would lead to actions protecting long-term plant health, particularly during periods of chronic overpopulation that coincide with periods of low precipitation.

WICA vegetation personnel collected vegetation use data using NRCS transect methodology between 2004 and 2008 to validate wildlife population size recommendations and characterize herbage status. However, monitoring annual herbage use on rangelands by direct clipping measurements is problematic due to the difficulty and expense of obtaining an adequate sample size of sufficient precision (Uresk and Mergen 2012). WICA has not been able to make the commitments of personnel and time to consistently collect data using NRCS transect methodology over time.

The modified Robel pole was calibrated for meadows and grasslands in the southern Black Hills in 2009 (Uresk et al. 2009). In 2010, WICA vegetation management staff chose the southern Black Hills modified Robel pole protocol to monitor residual herbage in WICA. The primary objective of the project was to determine condition of residual herbage on a park-wide basis. Data were collected from 2010 through 2013 during a time period of generally above-normal annual precipitation (Appendix A). The results, presented in this report, provide a baseline for upland residual herbage that summarizes impacts of actual wildlife populations on actual herbage in WICA.

Consideration of annual Robel results can stimulate discussion of alternative management options as impacts to residual herbage are observed over time (from varying animal population sizes, drought, etc.). In addition, residual herbage data summaries can be completed immediately after data are collected (within a few weeks after the growing season ends) which allows time for an effective response to protect vegetation resources when needed.

Residual herbage is just one component to consider in assessing ecological health of WICA relative to herbivores. Another important rangeland resource is water. Coupling residual herbage monitoring with stream monitoring could provide a strong foundation for assessing ecological conditions and making sustainable management decisions that is more robust than a foundation based on either monitoring focus alone.

Methods

The modified Robel pole has been introduced in range management as an improved, accurate and cost-effective methodology (Benkobi et al. 2000; Uresk and Benzon 2007; Uresk et al. 2010) to meet increasing demand for intensive monitoring of vegetation for livestock grazing and wildlife habitat on public rangelands. The modified Robel pole uses a visual obstruction reading that is a combined height-density measurement of vegetation for monitoring residual standing herbage. Once the relationship between visual readings and standing herbage (standing live and dead vegetation) has been calibrated to actual measurements by clipping and weighing vegetation, the modified Robel pole provides a quick, accurate, and precise tool to estimate residual herbage. Because it has been calibrated to actual measurements of clipped vegetation, the modified Robel pole is more accurate than widely used ocular estimates (Bonham 1989).

The modified Robel pole was calibrated for meadows and grasslands in the southern Black Hills in 2009 (Uresk et al. 2009). In 2010, WICA vegetation management staff chose the modified Robel pole protocol calibrated for the southern Black Hills to monitor residual herbage in WICA. Data were collected from July to October in 2010 through 2013 (Table 1), overall a period of above-normal annual precipitation (Appendix A).

Table 1. Sampling dates and number of transects sampled in WICA Robel residual herbage project 2010 -2013.

Year	Sampling Dates	Areas sampled	Number of Robel transects
2010	July 26 August 2, 3, 5, 9, 11, 23, 25 September 2, 15, 30 October 5, 6	8 paired areas (mixed-grass prairie and mixed-grass prairie with prairie dogs: 16 areas x 4 transects each=64 transects) + 1 prairie areas with 3 management histories (burn/no bison graze, burn/bison graze, no burn/no bison graze: 3 areas x 4 transects each=12 transects) + 1 prairie area scheduled for prescribed burn in October 2010 (1 area x 4 transects=4 transects)	80
2011	August 2, 3, 4, 8, 9, 10, 24	All areas sampled in 2010 + 1 area in Beaver Creek terrace prairie (1 area x 4 transects=4 transects)	84
2012	July 25, 30, 31 August 1, 2, 6, 7	Same as 2011	84
2013	July 15, 17 August 19, 21, 22, 28 September 5, 6, 16	All areas sampled in 2011 + 5 prairie areas in Casey addition (5 areas [no bison, no prairie dogs] x 4 transects each=20 transects)	104

Sample Design

The sampling plan for the WICA residual herbage project developed over time as goals for the project were reformulated and refined. Initially, the sampling was designed primarily to investigate residual herbage in mixed-grass prairie and mixed-grass prairie with prairie dogs. Thus, sample areas in mixed-grass prairie were paired with nearby areas in mixed-grass prairie with prairie dogs. Data were collected in eight paired areas, distributed as evenly throughout the park as possible (Figure 2), with four transects in each area (eight areas in mixed-grass prairie paired with eight areas in mixed-grass prairie with prairie dogs) for a total of 64 transects. Twenty additional transects were read in three mixed-grass prairie areas selected with the goal of comparing residual herbage in areas with various combinations of burning (October 2010 American Elk prescribed burn, 2009 Headquarters prescribed burn) and bison grazing (Figure 2). However, the sample size in the grazing and burning combinations was not large enough to make any substantive conclusions from Robel data. A total of 80 transects was sampled in 2010 and a total of 84 transects was sampled 2011-2012 (Table 1).

In 2010, WICA was comprised of 28,295 acres (11,450 ha). In 2011, WICA acquired the Casey addition which added 5,556 acres (2,250 ha) to the WICA landbase [total current park area: 33,851 acres (13,700 ha)]. In 2013, 5 sampling areas in mixed-grass prairie were added in the Casey addition (four transects each) so a total of 104 transects were sampled in 2013 (Table 1).

All areas sampled in WICA Robel project are displayed in Figure 2. Polygons with solid outlines are areas selected in 2010-2012. Paired areas (mixed-grass prairie and mixed-grass prairie with prairie dogs) have the same solid color polygon outlines. Polygons with dashed outlines are in the Casey addition. There are currently no prairie dogs, no bison, and very limited elk use in the Casey addition.

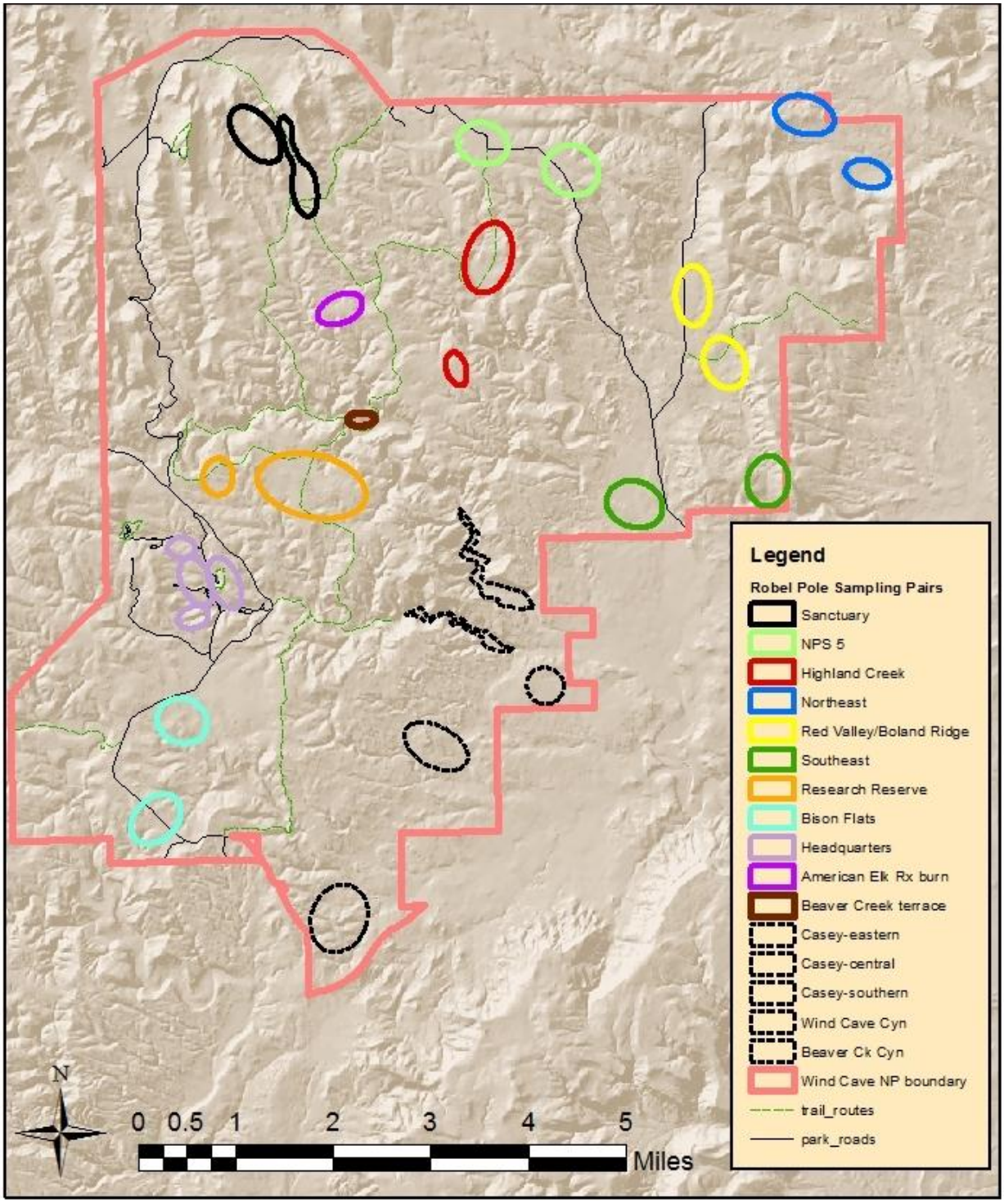


Figure 2. Sample areas in Wind Cave National Park for WICA Robel residual herbage project. In 2010- 2012, data were collected from eight paired areas (mixed-grass prairie and nearby mixed-grass prairie with prairie dogs) and three other prairie areas. These are displayed as polygons with solid outlines. Polygons with same-color solid outlines are pairs. In 2013, data were collected from all areas sampled 2010-2012 (solid outlines) plus the Casey addition (black-dashed outlines) for a total of 104 transects.

Data Collection and Analysis

Robel readings were done from mid-July to early October in 2010 - 2013. A modified Robel pole (Robel et al. 1970, Uresk et al. 2009) with 1.27 cm (0.5-inch) alternating white and black bands was used. The protocol specifies white and grey bands but the WICA equipment has white and black bands. The bands were numbered beginning with 0 at the bottom. Readings were made from a distance of 4 m with the reader's eyes at a height of 1 m (Figure 3). The number of the lowest visible band was recorded. WICA Robel data were collected with at least two people, one taking the reading and the other holding the center pole and recording data. At each pole station, four readings, one for each cardinal direction, were recorded and then averaged.

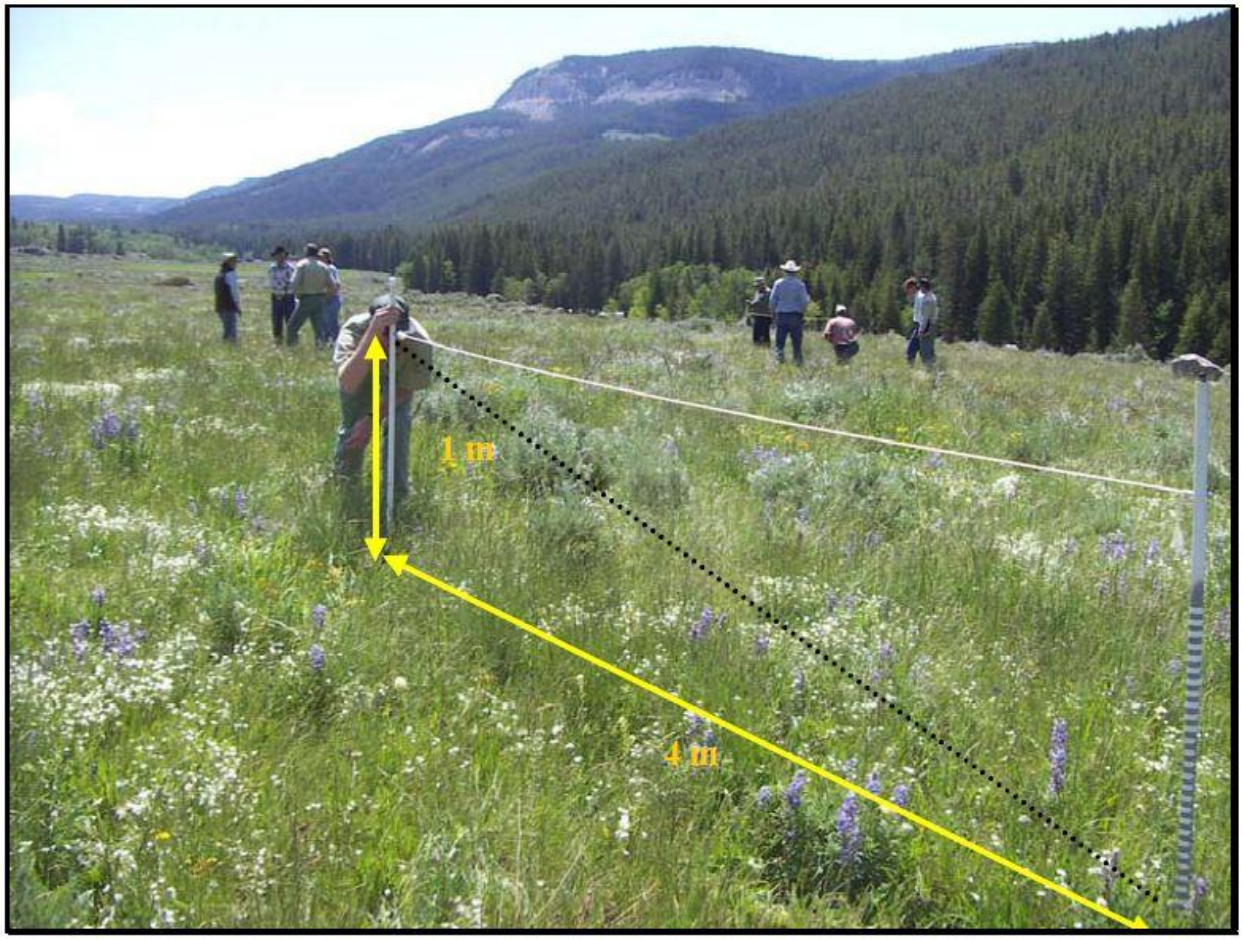


Figure 3. Illustration of procedure for visual obstruction readings following the modified Robel pole protocol. [From Uresk 2007 Black Hills Robel Pole Field Methods Workshop handout. Photograph from the Bighorn Mountains by D. Uresk and graphic enhancements by J. Javersak]

Each transect was 200 m long and four readings were recorded at each of 20 stations which were at 10 m intervals. All readings on a transect were averaged to provide a grand average band result for the transect. Four transects were sampled in each sample area and an average band determined (Uresk et al. 2009). This number described average residual herbage in the area and was also used to calculate herbage left ungrazed. Appendix D includes a sample Robel data spreadsheet.

Calibration formulas for the southern Black Hills from Uresk et al. 2009 were used to calculate herbage left ungrazed.
For bands over 3.6, herbage left ungrazed (kg/ha) = (68 x grand average band #) + 1080.
For bands 3.6 and under, herbage left ungrazed (kg/ha) = (306 x grand average band #) + 218.
Kilograms per hectare were converted to pounds per acre for summaries in this report (kg/ha x .0893 = lb/ac).

The primary standards used for interpretation of WICA Robel data were:

1) Band 3 in the southern Black Hills represents 60% residual herbage and is recommended as minimum residual herbage to conserve long-term health of plants and rangeland (Uresk et al. 2009).
2) Band 5 is recommended to maintain prairie dogs with limited or no expansion (Uresk and Mergen 2012).

Statistical analysis was completed with the data from the Robel area pairs (mixed-grass prairie and mixed-grass prairie with prairie dogs) for 2010 through 2013 and used to consider project results relative to the standards above. Results are presented in the form of box plots, displaying the distributional characteristics of the results as well as the results.

Results are also summarized in the form of a condition status/change assessment. A Natural Resource Condition Table based on templates from the State of the Park report series (http://www1.nrintra.nps.gov/im/stateoftheparks/index.cfm) was developed. The goal of the Natural Resource Condition Table is to synthesize and communicate complex park condition information to the public in a clear and simple way. It was an effective format to communicate overall condition of WICA residual herbage.

Results

In mixed-grass prairie, average Robel band values ranged from 3.7 to 22.0 with the lowest values for a given Robel area usually occurring in 2012 and the highest usually occurring in 2011 (Figure 4). 2012 was by far the driest of the four years in which sampling was conducted (Figure 5; Appendix A). Band values for all areas remained above the target value of band 3 for conserving long-term rangeland health in all years.

In mixed-grass prairie with prairie dogs, average Robel band values ranged from 0.78 to 9.5 but variations among years were not as consistent as in mixed-grass prairie (Figure 6). Twenty-eight band values (out of 32 total in mixed-grass prairie with prairie dogs) were below the target value of band 5 indicating vegetation suitable for maintaining prairie dogs, with some potential for expansion. Seventeen band values (out of 32 total) were below the target value of band 3for conserving long-term rangeland health. See Appendix B for a summary data table of results for all sampling areas in all years.

The average band reading for WICA (pre-2011 boundary; grazed by bison and other large herbivores) in mixed-grass prairie is 7.7. The average band reading for Casey addition mixed-grass prairie (no bison or other herds of large herbivores) is 6.1.

In the Casey addition in 2013, small mixed-grass prairie stands in Beaver Creek Canyon and Wind Cave Canyon had the greatest residual herbage (average bands 9.0 and 6.7, respectively). The larger mixed-grass prairie areas in the Casey addition averaged band 5.0. Large areas of the Casey addition's mixed-grass prairie have greater representation of shortgrass plant species than mixed-grass prairie within the pre-2011 WICA boundary. This may partially explain why ungrazed Casey addition mixed-grass prairie (average band 5.0) has significantly less residual herbage than grazed mixed-grass prairie in the eastern half of pre-2011 WICA (average band 13.8). Dead plant material that has not been removed by grazing or burning in the last decade in the Casey addition could contribute to less vigorous grassland, although significant thatch was not observed during Robel pole sampling. Another possible factor contributing to higher shortgrass component may be intensive historical grazing.

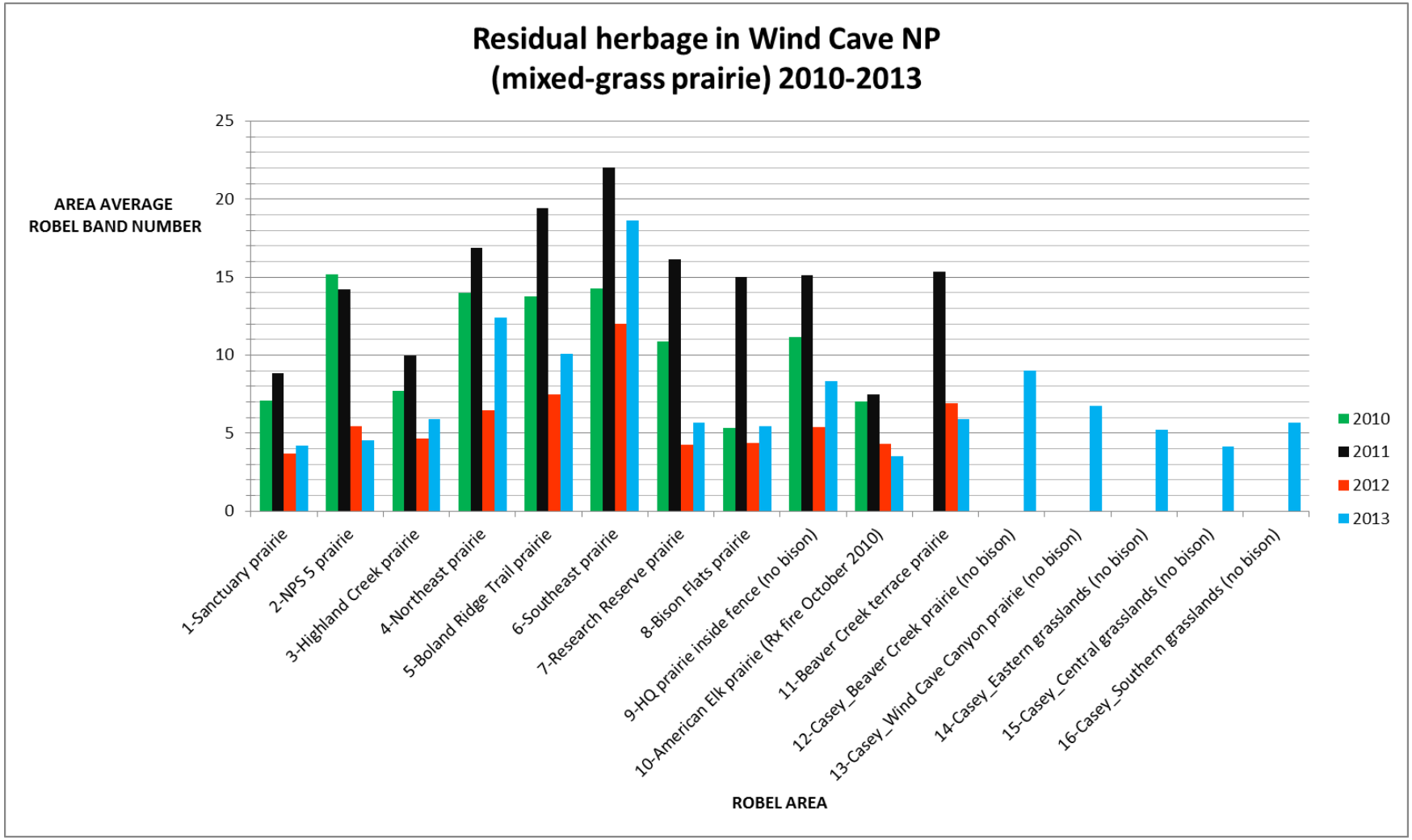


Figure 4. Residual herbage displayed as Robel band number in WICA sampling areas in mixed-grass prairie from 2010 through 2013. Note: data were collected in sample area 11 (Beaver Creek terrace prairie) starting in 2011; data were collected in sample areas 12 through 16 on the Casey addition starting in 2013.

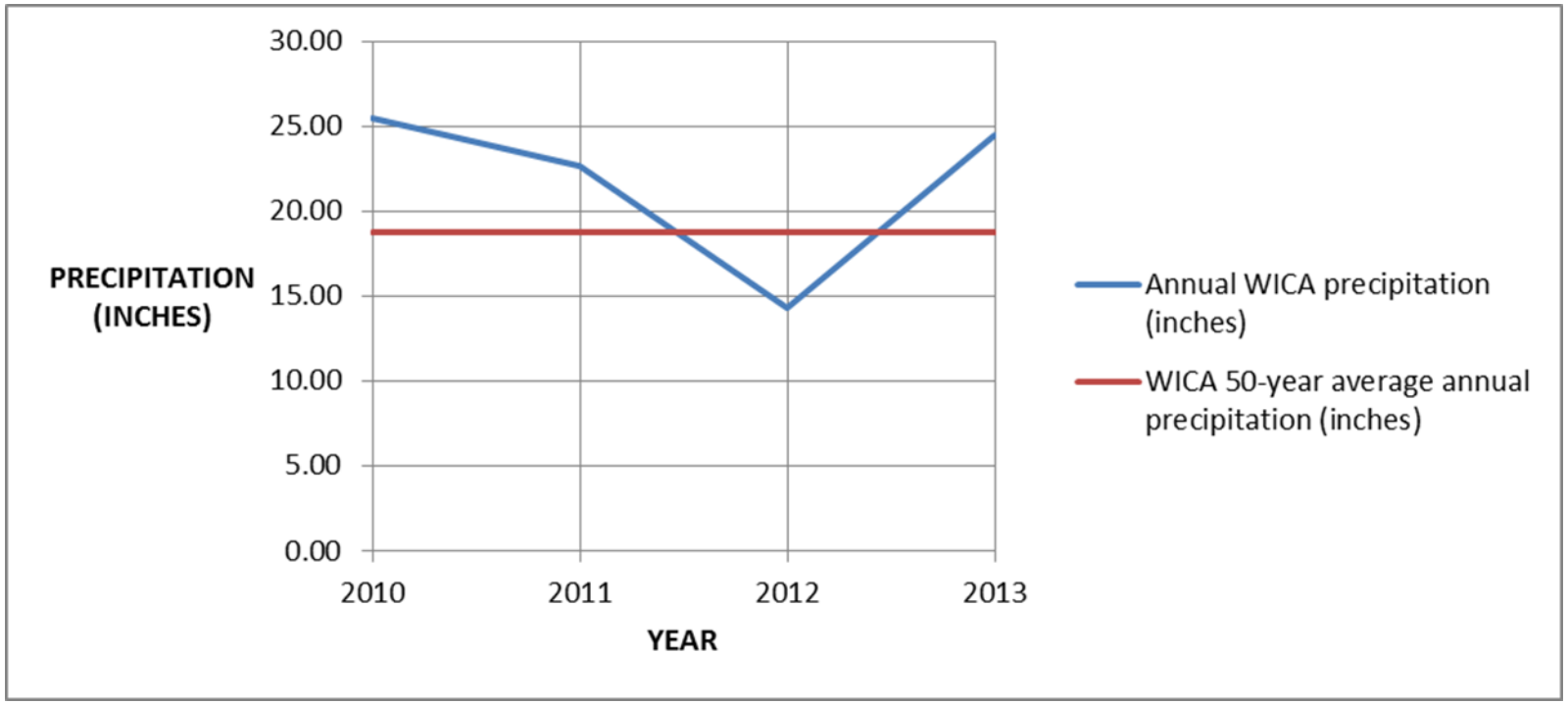


Figure 5. Precipitation data summary for period of WICA Robel project (2010 through 2013) from Wind Cave National Park precipitation records. See Appendix A for more detail.

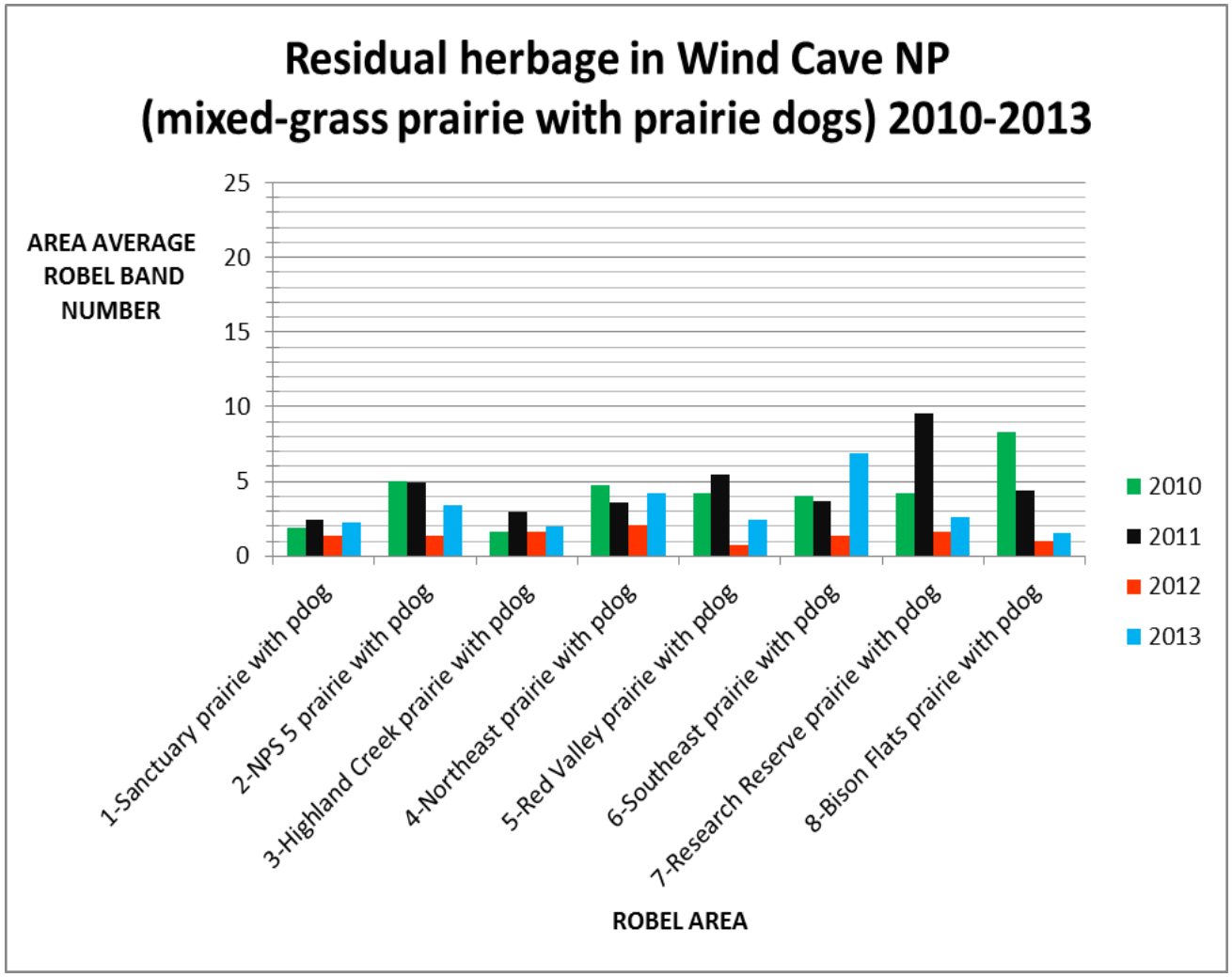


Figure 6. Residual herbage displayed as Robel band number in WICA sample areas in mixed-grass prairie with prairie dogs from 2010 through 2013.

Considering only the eight paired sampling areas, mean Robel band values were substantially lower in mixed-grass prairie with prairie dogs than in mixed-grass prairie (Table 2), as expected.

Table 2. Mean Robel band values with 95% confidence interval by year for mixed-grass prairie and mixed-grass prairie with prairie dog areas in WICA 2010-2013.

WICA Robel area type	Year	Number of Robel transects	Mean Robel band ± 95% confidence interval
Mixed-grass prairie with prairie dogs	2010	8	4.2 ± 1.7
	2011	8	4.6 ± 1.8
	2012	8	1.4 ± 0.3
	2013	8	3.2 ± 1.4
Mixed-grass prairie	2010	8	11.0 ± 3.2
	2011	8	15.3 ± 3.7
	2012	8	6.0 ± 2.3
	2013	8	8.4 ± 4.2

Also considering only the eight paired sampling areas, median band values in mixed-grass prairie remained above 3 in all sampling years. However in 2012, the median was just above 5, substantially lower than in the preceding two years (Figure 7). Median band value remained low in 2013, but the distribution of band values was much broader (toward higher values) than in 2012. In mixed-grass with prairie dogs, the median band value was below 5 in all years and below 3 in 2012, with some recovery in 2013 (Figure 7). Band value varied much less in mixed-grass prairie with prairie dogs than in mixed-grass prairie.

Photographs of representative areas of mixed-grass prairie (Figure 8, set 1) and mixed-grass prairie with prairie dogs (Figure 8, set 2) illustrate what various Robel band values look like in the field, as well as vegetation structure differences between the two types of areas.

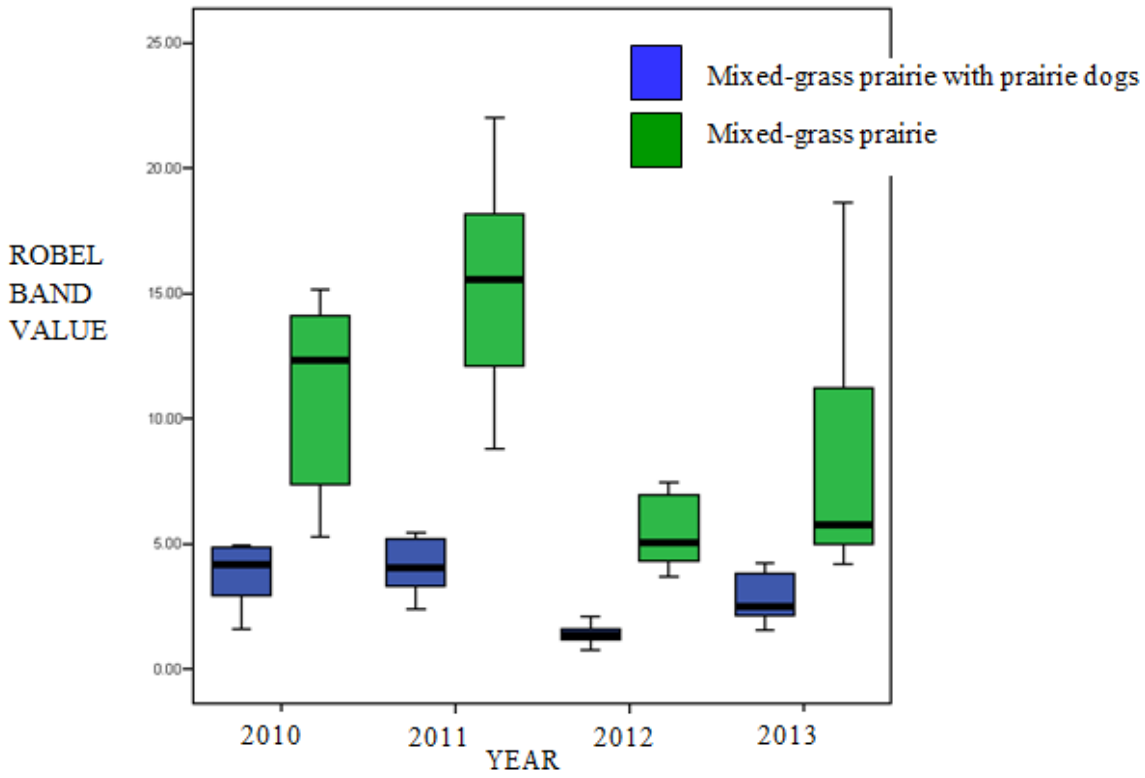


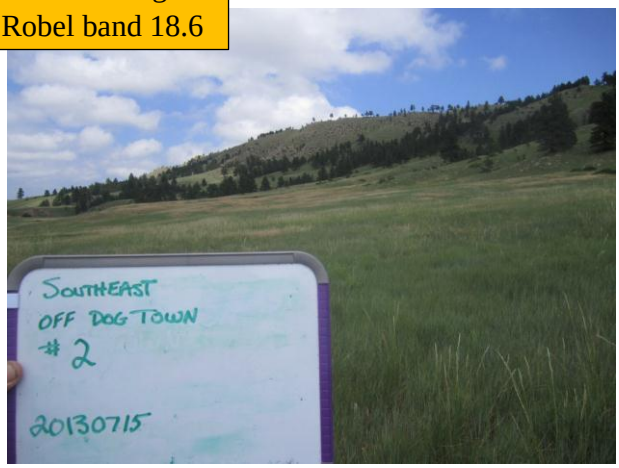
Figure 7. Comparison of median Robel band values in mixed-grass prairie (green boxes) and mixed-grass-prairie with prairie dogs (blue boxes) in sixteen sampling areas at WICA 2010-2013. In each box, the heavy black line indicates the median value, boxes encompass the 25th to 75th percentiles, and whiskers (thin lines extending beyond the boxes) indicate 10th and 90th percentiles. Appendix C provides background information on box plots.

Set 1- Sampling area: Southeast corner (mixed-grass prairie). Clockwise from top left: photographs from 2010, 2011, 2012 and 2013

Grand average Robel band 14.3

Grand average Robel band 22.0

Grand average Robel band 18.6



Grand average Robel band 12.0

Series 2 – Sampling area: Southeast prairie dog town (mixed-grass prairie with prairie dogs). Clockwise from top left: photographs from 2010, 2011, 2012 and 2013.

Figure 8. Photographs of transect locations in two sampling areas in each year of the WICA Robel project (2011-2013). Set 1: mixed-grass prairie. Set 2: mixed-grass prairie with prairie dogs.

Discussion

Residual herbage measurements can be compared to standards and recommendations for residual herbage developed by range ecologists to ensure protection of long-term plant and rangeland health. Residual herbage approximating 60% of potential yield supports long term health of rangeland plants. In wet years, economic return (e.g. in a livestock ranch operation) and herbivore health (e.g. in a wildlife reserve) are maximized and in dry years, negative impacts of overgrazing vegetation is minimal or avoided (Uresk and Mergen 2012). Adequate residual herbage is also important for preventing water erosion at the start of the next season because it supports soil water storage and provides physical barriers to water run-off and sediment movement. Adequate residual herbage reduces wind speed and sheer at the soil surface, reducing wind erosion and soil water evaporation (Lal 1994).

Direct measurement of herbage utilization is difficult. Commonly, vegetation is clipped inside and outside exclosures or cages that prevent livestock grazing. The process is time-consuming, expensive and difficult to achieve with adequate replication. Indirect methods, such as the widely used ocular method, avoid these difficulties but suffer from inaccuracy and observer bias (Schultz et al. 1961; Kershaw 1973; Block et al. 1987; Irving et al. 1995). The Robel pole protocol has been proven to be a simple, fast, precise, and economical tool to monitor standing vegetation.

WICA Robel project results indicate that the herbage areas of the park grazed by bison and other wildlife (sampled in all mixed-grass prairie WICA Robel sampling areas) were above band 3 in every year from 2010 through 2013 (Table 3). Band 3 corresponds to a residual of 60% of potential yield which is supportive of long-term plant health and rangeland ecological health in the southern Black Hills (Uresk et al. 2009). Precipitation was above the long-term average (Appendix A) for three of the four study years. Robel results for 2012, a below-average precipitation year, dropped sharply closer to band 3 and suggest that attention to annual Robel data could be important when several consecutive drought years occur (such as happened in WICA 2002 to 2007) to trigger management choices reducing vegetation stress and conserving long-term plant/rangeland health.

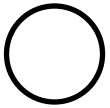
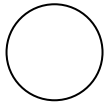
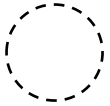
Prairie dogs are an important component of WICA wildlife and play a significant role in native grassland ecology at local and landscape scales. It is a high priority for WICA to maintain prairie dogs in the park to provide habitat and food for endangered black-footed ferrets that were reintroduced to WICA in 2007. WICA Robel project results indicate that vegetation in mixed-grass prairie with prairie dogs from 2010 through 2013 was below the level of band 5 recommended by Robel research (Uresk and Mergen 2012) to maintain prairie dog towns with limited or no expansion (Table 3). This indicates there was some potential for expansion. WICA goal for prairie dog acres is 1,000 to 3,000 acres (2006 WICA Black-tailed Prairie Dog Management Plan). Currently, WICA has 1,500 prairie dog acres (D. Roddy, pers. comm. 2014). A decrease in prairie dog acres has been recorded in WICA in recent years for reasons not fully understood but under investigation. WICA Robel results indicate that vegetation height/density likely interacts with other factors (e.g. white horehound (*Marrubium vulgare*) infestations, black-footed ferret populations) to influence extent of prairie dog acres.

Table 3. Summary of WICA Robel project results and conclusions on residual herbage condition (status and change) from 2010 to 2013. CI = Confidence Interval. See Table 4 for explanation of symbols.

Indicator of Condition	WICA Robel project analysis	Year	Ave Robel band ± 95% CI	Standard for Assessment	Condition Status/Change
Residual herbage	Residual herbage in mixed-grass prairie	2010	11.0 ± 3.2	**Robel band 3** corresponds to residual herbage that is 60% of potential yield and minimum to support long-term plant health and rangeland ecological health in southern Black Hills (Uresk et al. 2009).	
		2011	15.3 ± 3.7		
		2012	6.0 ± 2.3		
		2013	8.4 ± 4.2		
	Residual herbage in mixed-grass prairie with prairie dogs	2010	4.2 ± 1.7	**Robel band 5** is recommended visual obstruction reading to maintain prairie dog s with limited or no expansion (Uresk and Mergen 2012).	**Potential for expansion** 
		2011	4.6 ± 1.8		
		2012	1.4 ± 0.3		
		2013	3.2 ± 1.4		

Residual herbage is just one component to consider in assessing ecological health of WICA relative to herbivores. Another important rangeland resource is water. While WICA Robel data indicate that the park's vegetation resource was in good condition during these four years of mostly higher-than-average precipitation, monitoring of streambanks and streamside vegetation on perennial streams (2009 through 2013) using the BLM's Multiple Indicator Monitoring (MIM) protocol indicates that stream resources are in poor ecological condition primarily as a result of wildlife impacts and there have been no trends indicating improvement through time (Burkhart and Kovacs 2013; Burkhart and Kovacs 2014 in process).

Table 4. Key to symbols used in the residual herbage condition table. The background color represents the current status, the arrow summarizes the change/trend, and the thickness of the outside line represents the degree of confidence in the assessment. Based on the State of the Park reports (http://www1.nrintra.nps.gov/im/stateoftheparks/index.cfm).

Status		Change/Trend		Confidence	
	Significant Concern		Condition is Improving		High
	Caution		Condition is Unchanging		Medium
	Good Condition		Condition is Deteriorating		Low

For decades, attention has been focused in WICA on forage estimates and allocation to wildlife species while protecting plant health. However, there has been minimal investigation into riparian vegetation (composition and condition) and streams/streambanks condition (e.g., cover, stability, sediment load). Results of herbage and stream monitoring in 2010-2013 suggest that under recent past and current management, water is a limiting factor for WICA ecological health compared to vegetation. That is, the present numbers of wildlife (in present management style) are causing poor surface water resource condition while vegetation resources (as monitored for the last four years) have been maintained in good condition.

Primary water resources in WICA are composed of 3 perennial streams providing a total of approximately 5.5 miles of narrow stream (ca .5 to 3 m wide) in a landscape of 33,851 total acres (13,700 ha). Despite some topographic challenges, assessment results indicate that wildlife access and utilize virtually all stream resources in the park (Burkhart and Kovacs 2013). Approximately 15 of WICA's springs and 14 small impoundments have been developed for wildlife use since the 1930s but many of these improvements are not fully functional today. Wildlife use is the primary ecological service that WICA streams are currently providing, with other services lacking (e.g., herbage and browse production; plant and animal species richness and compositional, structural, and functional diversity; and hydrologic function; Burkhart and Kovacs 2013).

Management sustaining good ecological conditions must address limiting factors. Management options at WICA to improve stream condition exist in at least three areas:

1) Increase surface water availability.
   Increasing water in streams is difficult or perhaps not possible. Developing springs and seeps could increase water availability to a small degree. Providing water to wildlife from wells (especially on the Casey addition which has no perennial streams) has potential to significantly increase water availability. However, using groundwater for surface purposes would have to be considered in light of loss of groundwater for underground processes in Wind Cave.
2) Manage wildlife access/use of streams.
   A lack of barricades (temporary and permanent) currently does not allow for any options to manage wildlife access to WICA streams. Free-ranging wildlife provide benefits for visitor experience and some natural processes. However, WICA is too small a landbase for large herbivores to be considered as behaving in a natural, free-range manner (e.g., in a drought period, wildlife would leave WICA, given the opportunity, for more dependable water sources such as Beaver Creek springs in Buffalo Gap or the Cheyenne River).
3) Decrease wildlife numbers.
   Decreasing wildlife population numbers to levels supporting rehabilitation of WICA streams is a viable management option but can be complicated to implement. The park is actively working to reduce its elk herd to target populations as described in the 2006 WICA Elk Management Plan. However, it is possible that wildlife numbers needed to accomplish stream rehabilitation in a free-ranging management scenario might be so low that it would impinge on other WICA wildlife goals (e.g., maintain 400-500 bison in WICA to conserve the valued genetics of WICA bison herd).

There are no easy or simple solutions. The WICA MIM report (Burkhart and Kovacs 2013) suggests development of a WICA surface water protection strategy to carefully consider management options and determine ways to achieve long-term stewardship of WICA water resources. This would be one step in the direction of informed, considered management.

Both water and vegetation must be wisely managed to meet long-term natural resource stewardship goals at WICA. It may be possible for residual herbage to become a limiting factor at WICA in the future – for example, if groundwater sources are maximized while drought and climate change reduce total and seasonal vegetation productivity (King et al. 2013). Monitoring residual herbage in real-time, as the Robel pole protocol allows and the WICA Robel project 2010-2013 demonstrates, is an important tool for keeping a pulse on WICA vegetation condition

The WICA Robel project used a simple, precise, and economical tool (the Robel pole calibrated for the southern Black Hills) to characterize WICA herbage over four years (2010 through 2013). The results provide a baseline for WICA herbage in a period of generally above-average precipitation. It will be informative and perhaps critical to continue Robel data collection into a future likely to include drought periods similar to or more intense than those in the past (King et al. 2013). Residual herbage data can provide an early warning system for vegetation resources under stress and combine with other resource monitoring to maximize the time available for making management choices that conserve all intertwined park resources (e.g., grazed vegetation, non-grazed vegetation, surface water, soils, and wildlife).

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Appendix A: Precipitation data for Wind Cave National Park 2009-2013

The monthly and total precipitation data by year is from Wind Cave National Park precipitation records.

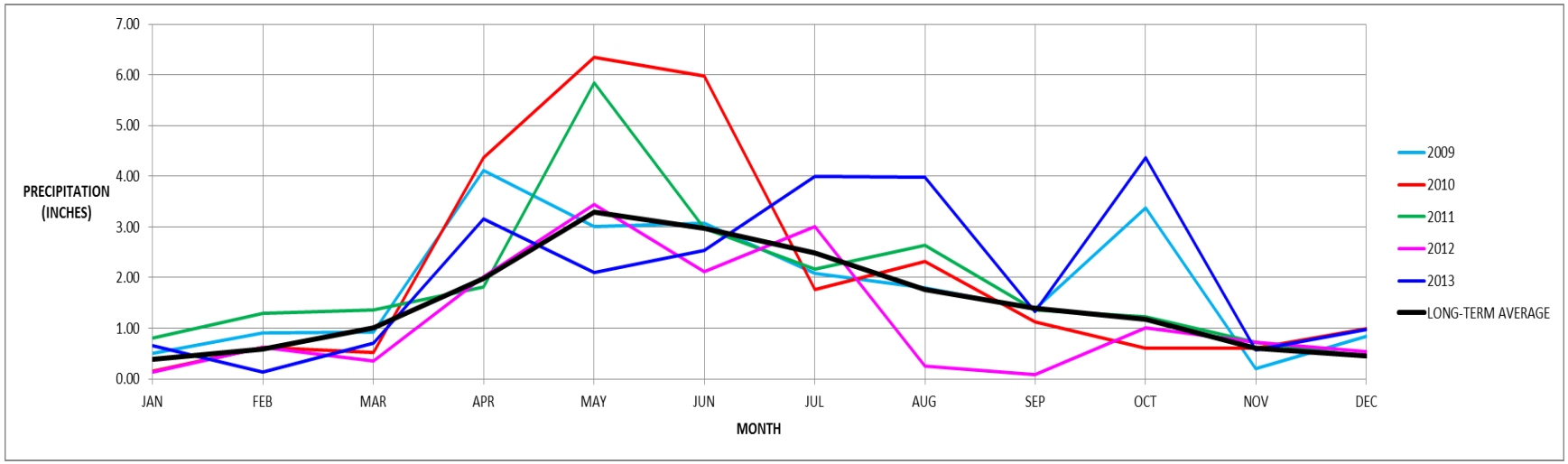
The long-term average was calculated from all available data from Wind Cave NP weather data collections from January 1952 to December 2013 and submitted to the National Weather Service (B. Muenchau pers. comm. 2013).

WIND CAVE NATIONAL PARK PRECIPITATION RECORDS (measured in inches)

Precipitation recorded from Wind Cave rain guage and collected by LE/RM. Wind Cave Elk Mt. Weather station and air quality station used for backup.

Documentation by Barbara Muenchau, WICA BioTech

YEARS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		YEAR	Total
2009	0.51	0.9	0.93	4.11	3.01	3.07	2.08	1.8	1.37	3.37	0.21	0.84		2009	22.20
2010	0.16	0.62	0.53	4.37	6.35	5.97	1.77	2.31	1.13	0.61	0.61	1.00		2010	25.43
2011	0.8	1.29	1.36	1.81	5.84	2.98	2.17	2.64	1.36	1.23	0.72	0.43		2011	22.63
2012	0.13	0.62	0.35	2.02	3.45	2.11	3.00	0.26	0.09	1.01	0.72	0.54		2012	14.30
2013	0.66	0.13	0.7	3.15	2.1	2.53	4.00	3.98	1.32	4.36	0.58	0.98		2013	24.49
LONG-TERM AVERAGE	0.38	0.60	1.01	1.98	3.30	2.98	2.48	1.76	1.39	1.18	0.60	0.46		LT AVE	18.12



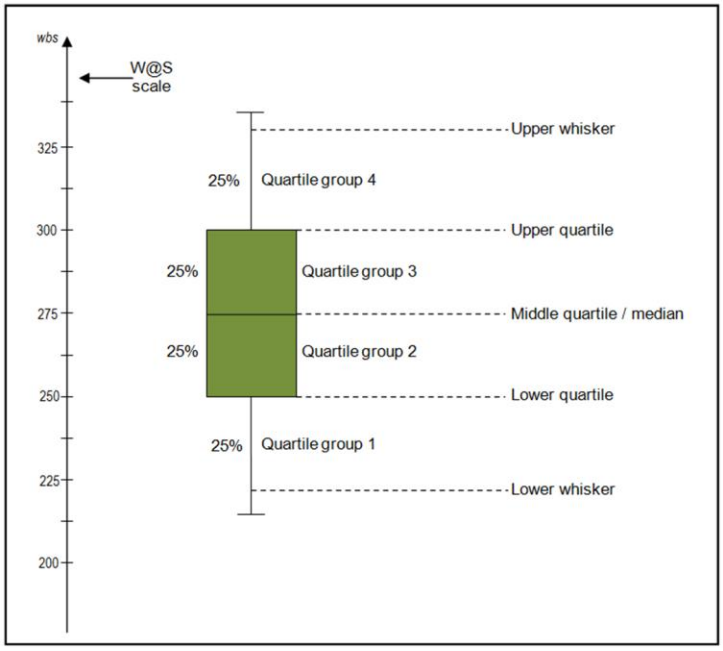
Appendix B: Wind Cave NP Robel project data summary – 2010-2013

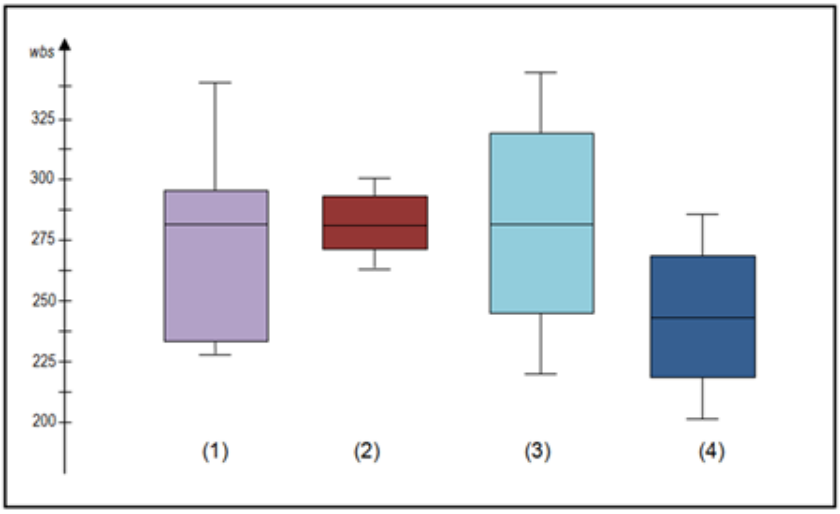
WICA Robel data summary 2010 - 2013 presenting grand average Robel bands and residual herbage (kilograms/hectare and pounds/acre) for all WICA Robel sample areas. Residual herbage was calculated using southern Black Hills calibration formulas (Uresk et al. 2009).

LOCATION	2010 average band	2010 residual herbage kg/ha	2010 residual herbage lb/ac	2011 average band	2011 residual herbage kg/ha	2011 residual herbage lb/ac	2012 average band	2012 residual herbage kg/ha	2012 residual herbage lb/ac	2013 average band	2013 residual herbage kg/ha	2013 residual herbage lb/ac
1-Sanctuary prairie with pdog	1.9	790.2	705.7	2.4	952.4	850.5	1.3	628.0	560.8	2.3	909.6	812.2
1-Sanctuary prairie	7.1	1560.1	1393.2	8.8	1679.1	1499.4	3.7	1330.2	1187.9	4.2	1365.6	1219.5
2-NPS 5 prairie with pdog	5.0	1418.0	1266.2	4.9	1415.2	1263.8	1.4	637.2	569.0	3.4	1255.3	1121.0
2-NPS 5	15.2	2110.9	1885.0	14.2	2048.3	1829.1	5.5	1451.3	1296.0	4.6	1390.1	1241.3
3-Highland Creek prairie with pdog	1.6	707.6	631.9	3.0	1136.0	1014.4	1.6	719.8	642.8	2.0	1216.7	1086.5
3-Highland Creek prairie	7.7	1602.2	1430.8	9.9	1755.9	1568.0	4.6	1395.5	1246.2	5.9	1479.2	1320.9
4-Northeast prairie with pdog	4.8	1403.7	1253.5	3.6	1326.2	1184.3	2.1	863.7	771.2	4.2	1367.0	1220.7
4-Northeast prairie	14.0	2030.6	1813.4	16.9	2229.2	1990.7	6.4	1517.2	1354.9	12.4	1923.2	1717.4
5-Red Valley prairie with pdog	4.2	1364.2	1218.3	5.5	1452.0	1296.6	0.8	456.7	407.8	2.4	961.6	858.7
5-Boland Ridge Trail prairie	13.8	2015.7	1800.0	19.4	2400.6	2143.7	7.5	1588.6	1418.7	10.1	1764.8	1575.9
6-Southeast prairie with pdog	4.0	1353.4	1208.6	3.7	1328.2	1186.1	1.3	628.0	560.8	6.9	1549.9	1384.0
6-Southeast prairie	14.3	2051.0	1831.6	22.0	2576.7	2301.0	12.0	1895.3	1692.5	18.6	2346.2	2095.1
7-Research Reserve prairie with pdog	4.2	1364.9	1218.9	9.5	1727.4	1542.5	1.6	707.6	631.9	2.6	1004.4	896.9
7-Research Reserve prairie	10.9	1819.8	1625.1	16.1	2176.8	1943.9	4.3	1369.7	1223.1	5.6	1463.5	1306.9
8-Bison Flats prairie with pdog	8.3	1645.1	1469.1	4.4	1381.2	1233.4	1.1	539.3	481.6	1.5	689.2	615.5
8-Bison Flats prairie	5.3	1440.4	1286.3	15.0	2101.4	1876.5	4.4	1377.8	1230.4	5.5	1451.3	1296.0
9-HQ West prairie inside fence (burn and no bison graze)	11.2	1838.2	1641.5	15.1	2109.5	1883.8	5.4	1447.2	1292.3	8.3	1645.8	1469.7
9-HQ West prairie outside fence (burn and bison graze)	7.7	1604.3	1432.6	12.0	1898.7	1695.6	5.7	1469.0	1311.8	not sampled	not sampled	not sampled
9-Prairie Vista prairie inside fence (no burn and no bison graze)	11.5	1864.0	1664.6	16.9	2231.9	1993.1	7.2	1567.6	1399.8	8.3	1645.8	1469.7
10-American Elk prairie (Rx burn October 2010)	7.0	1558.0	1391.3	7.5	1590.0	1419.9	4.3	1373.8	1226.8	3.5	1292.1	1153.8
11-Beaver Creek terrace prairie	not sampled	not sampled	not sampled	15.4	2123.8	1896.6	6.9	1548.5	1382.8	5.9	1479.2	1320.9
12-Casey_Beaver Creek prairie (no bison)	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	9.0	1692.0	1511.0
13-Casey_Wind Cave Cnyn prairie (no bison)	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	6.7	1537.0	1372.5
14-Casey_Eastern grasslands (no bison)	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	5.2	1435.0	1281.4
15-Casey_Central grasslands (no bison)	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	4.1	1361.5	1215.8
16-Casey_Southern grasslands (no bison)	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	not sampled	5.7	1464.2	1307.5

Appendix C: Understanding box plots

Top: Box plots allow study of the distributional characteristics of a group of scores. To begin with, scores are sorted into four equal-sized groups. That is, 25% of all scores are placed into each group. The lines dividing the groups are called quartiles. The median (middle quartile), marks the mid-point of the data and is shown by the line that divides the box into two parts. Half the scores are greater than or equal to this value and half are less.
Bottom: Box plots with same median but different distributions – examples (1), (2) and (3). The medians are all at the same level but the box plots show very different data distributions. A short box indicates data with high level of agreement; a tall box indicates a wider spread of data. If the sections of the box plot are uneven in size, this indicates some parts of the scale are more variable than others. Obvious differences between box plots for comparative data (such as example (4) - box plot much lower or higher) or different distributions around the median are worthy of further investigation or discussion.





Appendix D: Sample Robel datasheet from a single transect

An Excel spreadsheet for use on mobile devices is available from Wind Cave NP or USDA Forest Service (developed by J. Javersak, USDA Forest Service).

Sta	n	s	e	w	AVE
1	2	2	3	2	2.25
2	3	4	3	2	3
3	3	3	3	4	3.25
4	4	4	3	2	3.25
5	4	3	4	2	3.25
6	1	2	3	2	2
7	3	7	3	3	4
8	2	5	5	3	3.75
9	6	1	2	8	4.25
10	2	4	2	2	2.5
11	3	4	3	3	3.25
12	3	3	3	4	3.25
13	4	7	8	8	6.75
14	6	1	3	0	2.5
15	0	2	2	2	1.5
16	2	3	3	2	2.5
17	1	1	2	1	1.25
18	2	3	0	1	1.5
19	3	0	4	0	1.75
20	3	6	3	2	3.5
mean	2.96				
kg/ha	840.8				
lbs/acre	749.1				